Interaction of Evacuating Building Occupants with First Responders in Tall Buildings
April 4, 2006

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Overview

I. Background and Objectives

II. Evacuation and Counterflow Data
   A. Evacuation of World Trade Center 1
   B. Evacuation of a Six Story Building

III. A Theory of Counterflow

IV. Future Solution

I. Background and Objectives

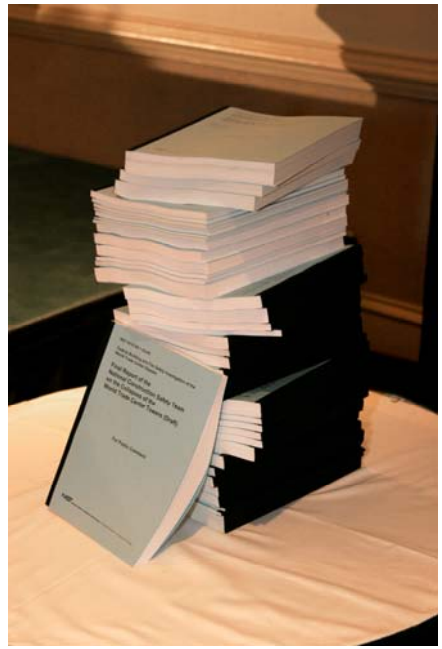
Background:

Recent high-profile events with significant loss of life have demonstrated that getting responders into and occupants out of buildings during emergencies is a problem and is costing lives

This project will:

- Provide the technical foundation for egress and access code requirements
- Work with codes and standards bodies to implement findings

II. Evacuation and Counterflow Data



A) NIST World Trade Center Investigation (110 Story)

- Causal Modeling (Multiple Regression Analysis)
  - 803 randomly sampled (by strata) interviews with WTC survivors

B) NIST Observation of Full Building Evacuation (6 Story)

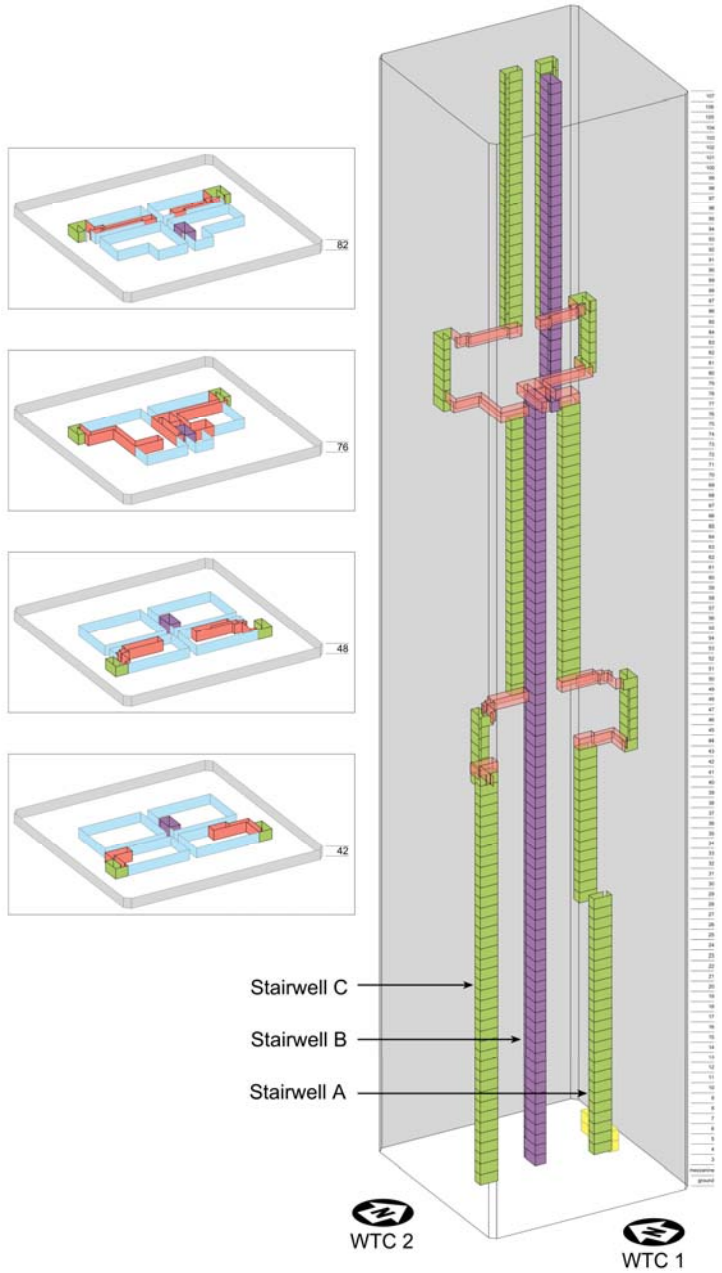
- 2005 Data Collection of Stairwells with and without emergency responder counterflow

II-A. WTC 1

3 Stairwells

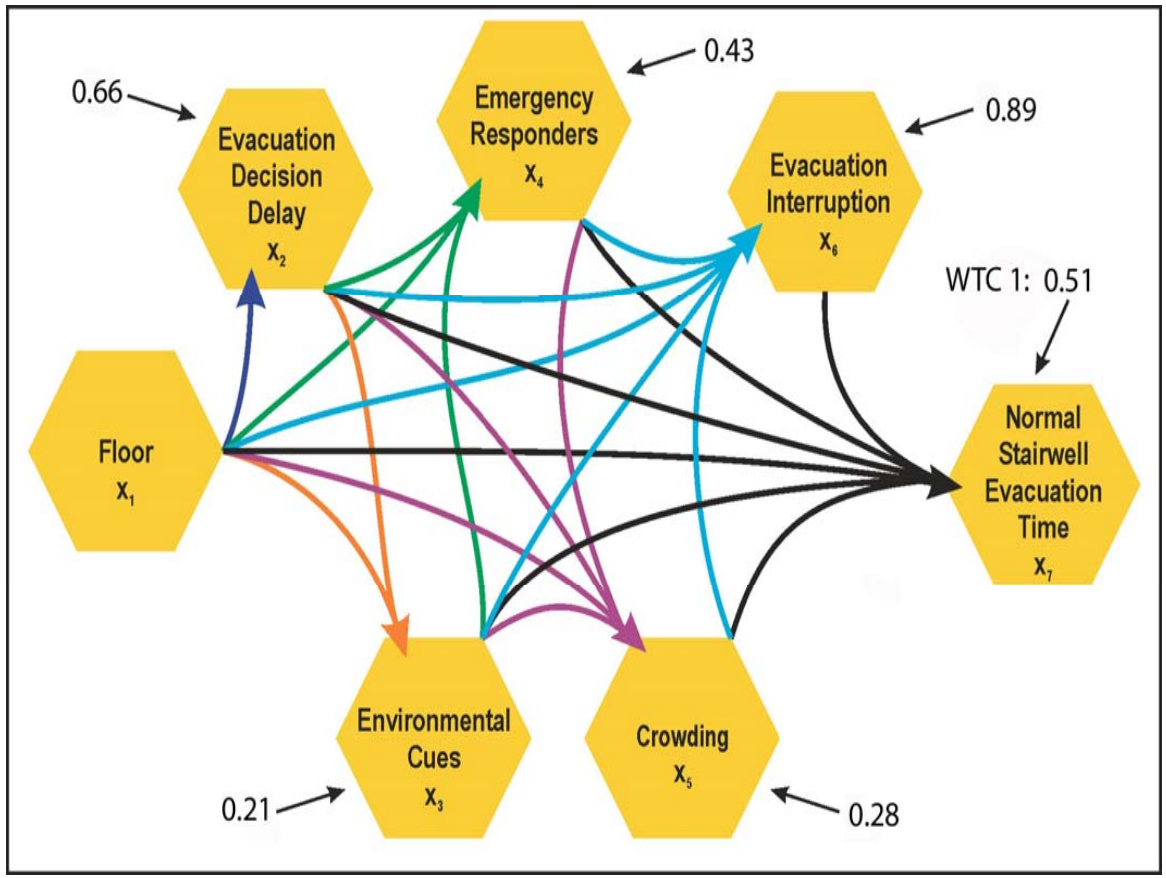
- **Two 44 in. Stairwells**
- **One 56 in. Stairwell (preferentially used by emergency responders)**

Transfer Hallways



II-A. WTC Causal Model

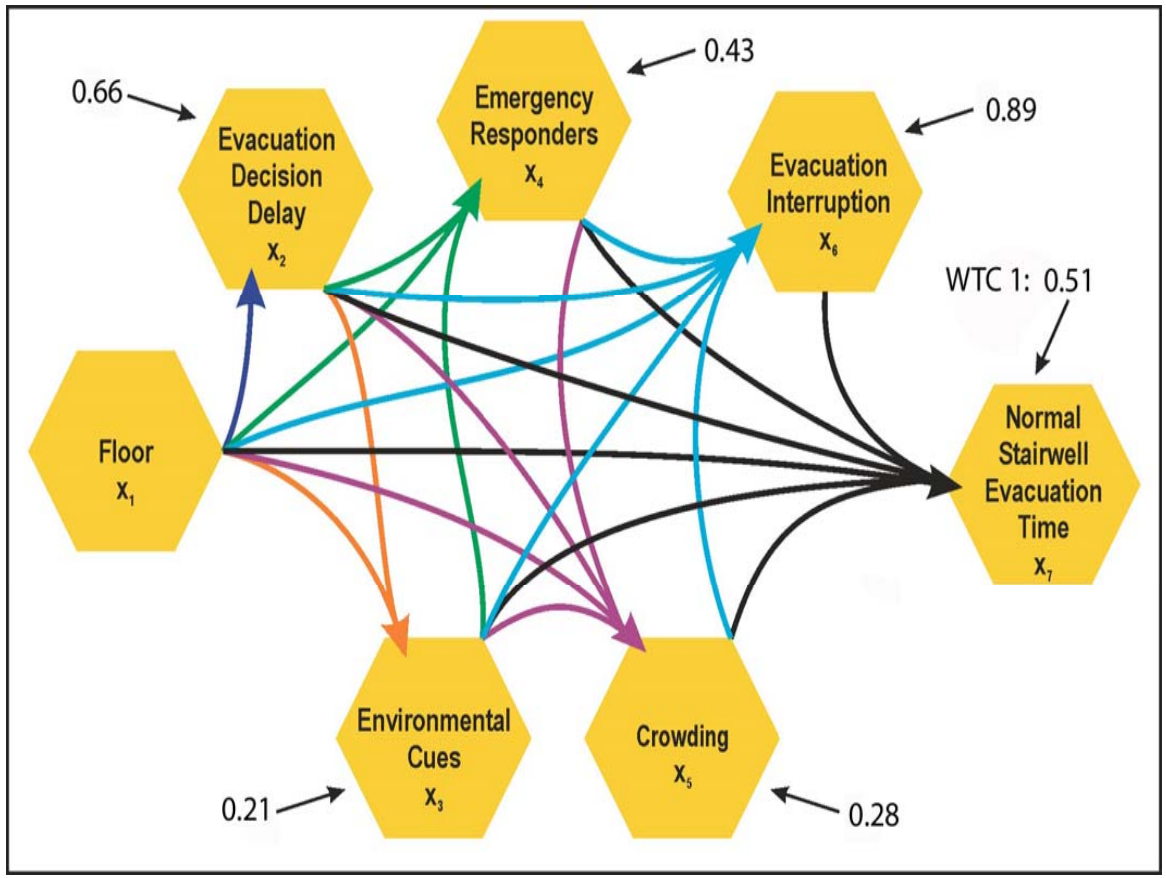
Floor (0.23) and environmental cues (0.56) (fire, smoke, etc) positively predicted encountering first responders. Encountering emergency responders did not predict longer evacuation times.



II-A. WTC Causal Model

Why?

The impact of emergency responder counterflow (0.09) on average time spent in the stairwell was not as important as other factors: distance traveled down the stairs (0.78) while encountering environmental cues (0.46) and, independently, interrupting one's evacuation (0.18).



II-B. Observation of Building Evacuation

Observation of 6 Story Building Evacuation

- Two Six Story Stairwells
  - 60½ inch (gross) stairwells
    - 55 inch clear width, handrail to handrail

- 277 Occupants in Two Stairs (127 & 150, respectively)

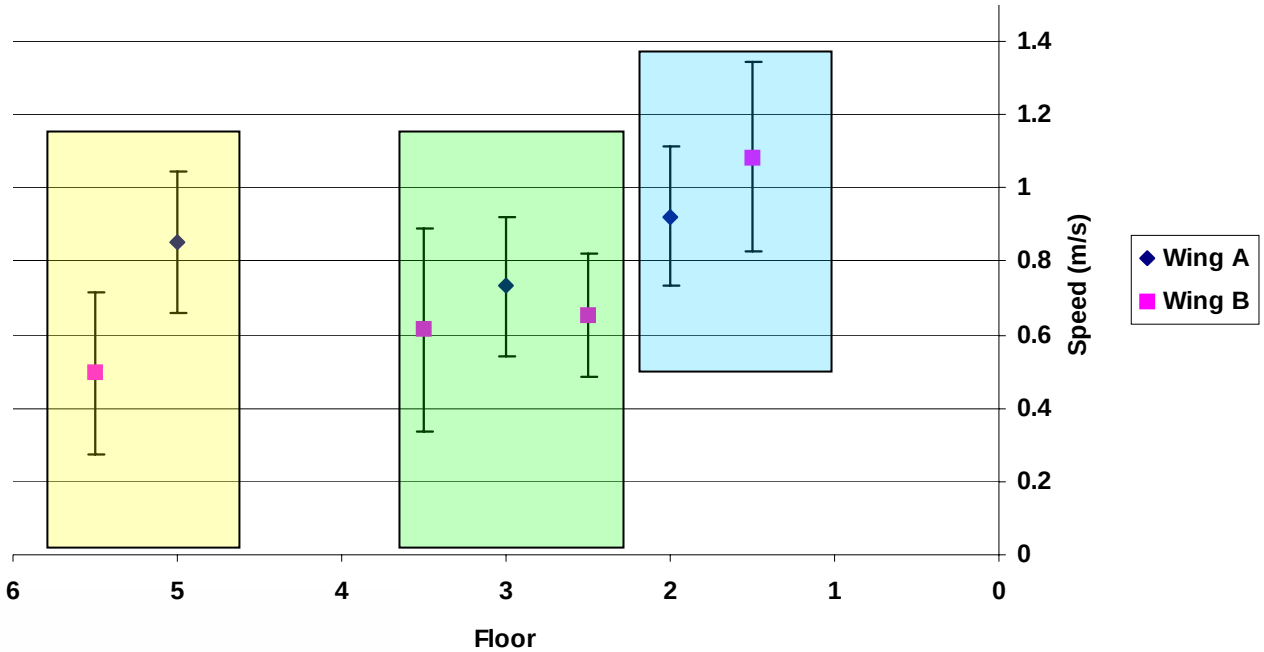
- Wing A – control stairwell (3 stair cameras, 1 at exit)

- Wing B - with firefighter counterflow: group of three firefighters each at 74 and 134 seconds (4 stair cameras, 1 at exit)

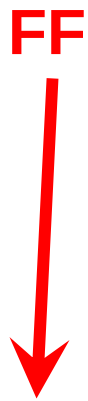
II-B. Observation of Building Evacuation

Average Downward Speed in Stairwell

- Without Counterflow: 0.8 ± 0.19 m/s
- With Counterflow: 0.70 ± 0.27 m/s



II-B. Observation of Building Evacuation



Working up the middle

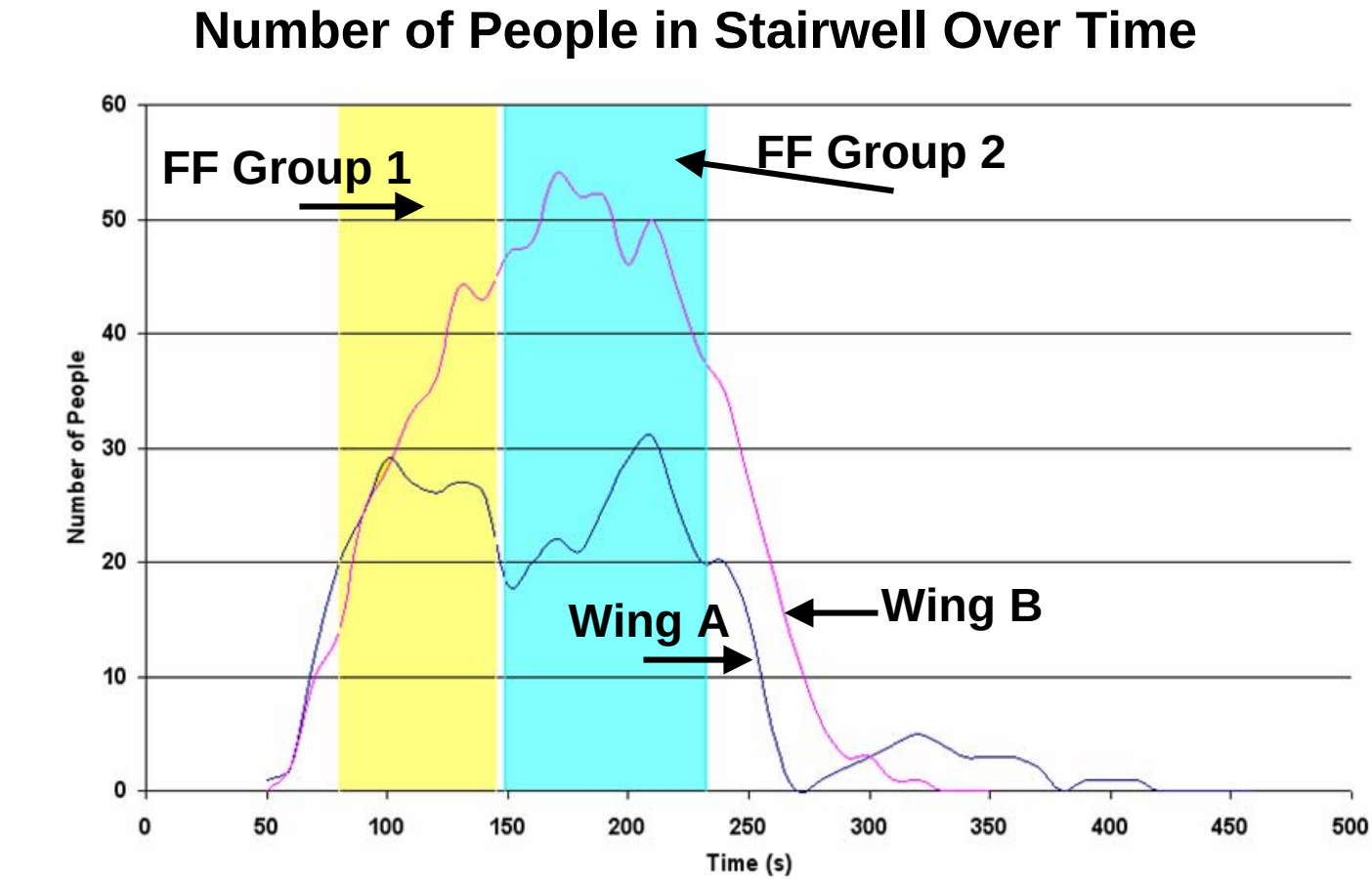
“Move to the right!”

II-B. Observation of Building Evacuation

Average Ascent Speed in Stairwell

- First Group of 3 Entered at 80 s.
  - Ascended from 1st to 5th floor in 65 s
  - Ascent speed of 0.99 m/s
- Second Group of 3 Entered at 149 s
  - Ascended from 1st to 5th floor in 83 s
  - Ascent speed of 0.75 m/s

II-B. Observation of Building Evacuation



III. Theory

Occupant A is moving at their comfortable mean free speed. Upon encountering an ascending emergency responder, the occupant will pause to let the responder by. Upon resuming evacuation, the occupant will continue moving at their previous mean free speed.

Occupant B is moving at a speed somewhat slower than their mean free speed. Upon encountering an ascending emergency responder, the occupant will pause to let the responder by. Upon resuming evacuation, the occupant will speed up in order to catch up to the occupants in front of them so that they are again moving at the previous speed.

III. Theory

Occupant A will show a reduction of speed of travel when compared to a similar occupant who did not encounter a first responder. This is due to the fact that the time lost to letting the first responder pass will not be made up for later by moving faster. The occupant was already moving as quickly as they were comfortable moving.

Occupant B will not show a reduction of speed of travel when compared to a similar occupant who did not encounter a first responder. This is due to the fact that the time lost to letting the first responder pass will be made up for later by moving faster. The occupant having made up the lost time, will resume moving at the pace of the occupants in front of them.

III. Theory

Reasons that an occupant may not move at their optimal speed:

- Encountering event-related obstacles (fire, smoke, wall damage, etc…)
- Fatigue
- Evacuation interruption (take a rest, make a telephone call, assist fellow evacuee, go to the restroom, get a drink…)
- Mobility impaired occupant below
- Blockage in the stairwell (storage)
- Carrying objects (briefcases, coffee)
- Choice of footwear

IV. Solutions

Protected Elevators

- Occupant Evacuation Elevators
  - May dramatically reduce total building evacuation time for tall buildings
  - Ideal solution for mobility impaired
  - Capacity already in place
  - Less physically taxing to occupants
- Firefighter Ingress Elevators
  - May dramatically reduce time to attack fire or perform search and rescue for tall buildings
  - Less physically taxing to responders

Acknowledgments

Analyst:
Jessica Kratchman
NIST / U. of Maryland

Data Collection:
Erica Kuligowski
NIST